

Preface

Plasma etching and deposition processes play a critical role in the production of high-density, high-performance microelectronic products. Generally, their underlying mechanisms consist of plasma-phase chemical reactions, particle transport, and surface reactions. Either one can dominate, depending on whether conditions are chosen to favor etching, deposition, or a combination of both. Each is a nonequilibrium process, making characterization quite complex. Nevertheless, considerable progress has been achieved in the development of plasma etching and deposition—and in the development of the reactor systems in which they are carried out. This issue contains papers that discuss relevant mechanisms; processing, system, and materials aspects; and potential advances.

Many of the dielectric layers of ULSI (ultralarge-scale integrated) semiconductor circuits (containing structures having minimum pattern widths of $0.25\text{ }\mu\text{m}$ and less) are patterned using plasma-assisted CVD (chemical vapor deposition). In the paper by D. R. Cote et al., the following relevant aspects are discussed: materials, processing, and device-related issues; deposition mechanisms; reactor design and process optimization; and considerations regarding extendibility to a wafer diameter of 300 mm.

Plasma etching is used to pattern many of the layers of ULSI circuits. M. Armacost et al. cover etching selectivity, masking material, multilayer structures, aspect ratio, self-aligned contact structures, microloading effects, device damage, and the use of high-density plasma sources.

Active-matrix liquid crystal displays make use of large-area arrays of thin-film transistors (TFTs) fabricated using amorphous silicon containing hydrogen (a-Si:H). Plasma deposition and etching play important roles in the fabrication of the arrays. The paper by Y. Kuo et al. covers the influence of plasma deposition and etching phenomena on the TFTs and associated films, factors affecting relevant etching rates and selectivity, control of the edge profiles of the various films used, and control of plasma-etching-induced damage to the TFTs.

The rapidly increasing area density of disk drives will probably soon make it necessary to employ plasma etching in the fabrication of magnetic recording heads. However, the thin-film materials used in the heads, such as Al_2O_3 , NiFe, Cu, Ta, and Au, differ from those used in silicon-based microelectronics applications. R. Hsiao discusses relevant broad-beam ion etching processes and the plasma etching of magnetic recording head materials.

With the introduction of new thin-film materials to consistently shrinking microelectronic devices and circuits, plasma-based process damage has become a serious concern. In addition to process flow, device and circuit layout can be a causal factor. These issues are discussed in the paper by S. J. Fonash.

High-density plasma chemical vapor deposition (HDP CVD) appears to be a promising alternative for the deposition of dielectric layers. Although in many respects layers deposited in that manner are superior to those deposited using conventional low-density plasma processes, metal contamination concerns remain to be satisfactorily addressed. Because of concurrent etching and deposition, the process can be an effective local planarization method for high-aspect-ratio structures. In S. V. Nguyen's paper, the following are discussed: HDP CVD processing and equipment aspects; the characterization of HDP CVD fluorinated and nonfluorinated SiO_2 films and carbon films; and applications in interlevel insulation, gap filling, and planarization.

Layer-formation processes having a low "thermal budget" are required for the manufacture of advanced semiconductor devices. Thin dielectrics, such as SiO_2 and Si_3N_4 , can be grown from a silicon substrate at low temperatures using plasma-based methods. D. W. Hess discusses the oxidation and anodization of silicon and silicon-germanium, including the influence of film crystallinity and the plasma source used; the mechanisms and processes of nitridation and oxynitridation; and nano-oxidation possibilities using an approach based on scanning tunneling microscopy or atomic force microscopy.

Because of their wide range of physical and chemical properties, diamondlike carbon (DLC) films prepared from PECVD are useful in a number of electrical, optical, and mechanical areas. They also appear to have potential for achieving low-dielectric-constant insulation in ULSI circuits. A. Grill discusses plasma-based DLC deposition; the structural, electrical, optical, mechanical, and tribological properties of DLC films; and associated applications.

Film deposition by sputtering in a plasma is a process that has seen extensive use for film deposition. As the aperture ratio of an integrated-circuit structure increases, conformal step coverage becomes increasingly difficult to achieve using conventional sputtering. S. M. Rossnagel covers this subject, including recent work on I-PVD (ionized physical vapor deposition), which, for high-aperture-ratio structures, appears to have many advantages over existing methods.

Surface reactions in plasma etching play an important role in determining the outcome of the etching. Although the reactions are difficult to delineate, many surface-characterization tools and techniques can be used to probe the etched surfaces for indications of possible reactions. The paper by G. S. Oehrlein et al. covers aspects pertaining to integrated circuits, with emphasis on the formation of self-aligned contacts to a polysilicon layer through a SiO_2 layer and a Si_3N_4 etch-stop layer.

Modeling and numerical simulation of plasma processes are important in the development of the processes and the

reactors in which they are implemented. S. Hamaguchi discusses the continuum and kinetic modeling and simulation of plasma sources as well as the modeling and simulation of the evolution of surface topography during plasma etching and deposition.

There is no doubt that plasma processing will continue to play a critical role in the fabrication of microelectronic products, but advances in the processes will likely become increasingly dependent on improved understanding of their underlying mechanisms.

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